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Biofunctionalized magnetic microdiscs applied in medicine

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Biocompatible magnetic microdiscs can be used in medicine for the treatment of malignant tumors [1]. These microdiscs are coated with gold (Au) and do not have a negative effect on the human body. Without the influence of the magnetic field, magnetic vortex is located in the center of the disc, when magnetic field is applied magnetic vortex shifts toward the increasing magnetization, creating an oscillation, which transmits mechanical force to the cell. Then this mechanical force is efficiently transduced to the membrane and after that to the subcellular components. We used a new approach to fabricate biocompatible microdiscs with a spin-vortex ground state. Dip-Pen Nanolithography (DPN) method is easy-to-use and it is flexible technique for fabrication of magnetic nanostructures. We used Au/Fe_3Si structure grown on Si(111) substrate [2] by molecular beam epitaxy (MBE) in extra-high vacuum on an atomically clean surface. In the experiment, by DPN method the ink (MHA-Acetonitrile) is deposited along the tracing path and diffuses away from the tip. This way we can form desired pattern, on a Fe_3Si/Si(111) substrate coated with Au. SiN probe, coated with ink was used in the experiment. By varying the dwell time, it is possible to create dots of various radii. We used 10 seconds for dwell time. Thus, this way structured array of 0.9-μm-diameter magnetic microdiscs (dots) was fabricated (Fig. 1a).

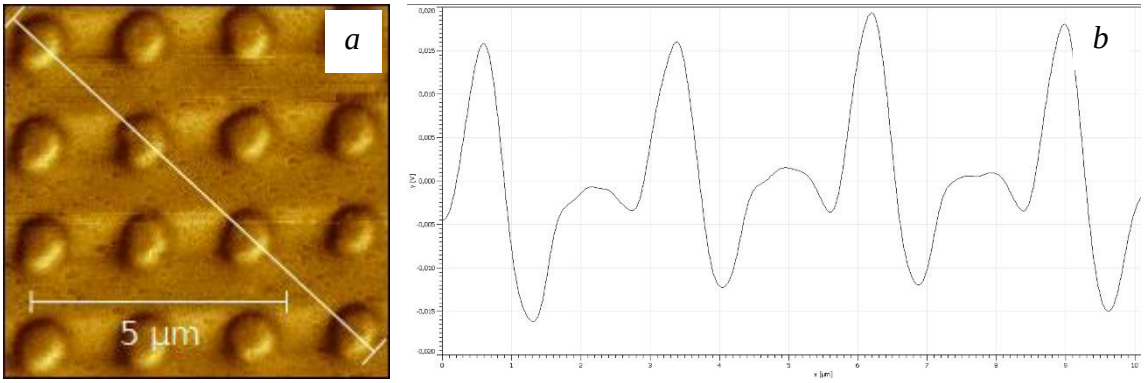

Figure 1. (a) MFM image and (b) the cross-section of MFM signal of Au/Fe_3Si microdiscs.

Fabricated nanostructured array of ferromagnetic microdiscs was studied by MFM mode to display the magnetic signal. The MFM probe used for the measurement was oriented perpendicular to the sample ($\alpha = 90°$) and the cantilever was tilted at an angle $\beta c = 4°$ with respect to the sample plane. With this probe configuration, the magnetic transitions appear as either dark or bright spots, corresponding to attractive or repulsive force derivatives, respectively. This response is shown explicitly by the constant force derivative contour in Figure 1b. Experimental MFM image microdiscs have the ground state of the homogenous magnetization, oriented along the direction of the external magnetic field. This image shows that all nanodiscs demonstrate the dipole distribution of MFM contrast typical for homogenous magnetized state.

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